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Technical Report

PROTECTION OF MOORING BUOYS

PART VII. RESULTS OF SIXTH RATING INSPECTION

December 1965

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

CONTENTS

INTRODUCTION

The presently specified coatings for mooring buoys have performed unsatisfactorily; consequently, the Bureau of Yards and Docks assigned the Naval Civil Engineering Laboratory to find or develop better corrosion protection for fleet mooring buoys. The assignment included investigation of both protective coatings and cathodic protection.

A field-test program was initiated in San Diego with fifteen peg-top riser-chain mooring buoys (Mark I or Mark II). Thirteen different coating systems were used, and a cathodic protection system was installed on one buoy of each of three pairs used in this part of the test program. The results of the program are published in a series. Technical Report R-246,[1] the first in the series, described the application of protective coatings and the installation of a cathodic protection system. Subsequent reports[2,3,4,5,6] describe the condition of the buoys from the first through the fifth rating inspections and the condition of the panels through their fourth rating inspection. This report describes the condition of the buoys at the time of their sixth rating inspection and the condition of the panels after 2-1/2 years of exposure.

SERVICE CONDITIONS

For the test, fifteen mooring buoys were placed in an area of North San Diego Bay that receives heavy service from the fleet. Some of the buoys were badly damaged by overriding vessels and by the abrasion of mooring lines and securing assemblies. Because it was necessary to place the test buoys in service a few at a time, and because there were long delays in obtaining acceptable specification coatings, placement required a long time. One set of thirteen panels was suspended from a pier in San Diego Bay and the other from a pier in Port Hueneme Harbor. A portion of each panel was continually submerged, another portion was intermittently submerged by rising tide, and a third portion was continually exposed to the atmosphere. The panels were not exposed to their harbor environments at the same time as the buoys; they were kept in storage until all of them had been coated. The panels were then placed in test position at the same time, rather than over a 6-month period as were the buoys. At the time of their fifth rating (described herein) they had been exposed for 2-1/2 years.

During the last 6 months all of the test buoys were removed and relocated. Some of the mooring numbers were changed. Care was taken during the relocation to minimize abrasion and impact damage. Because of the relocation and because of WESTPAC deployment, all test buoys had received only light service during the 6 months prior to the inspection.

INSPECTION PROCEDURE

Each of the test mooring buoys was inspected after it had been lifted onto the deck of a floating crane. The amount of fouling was determined, the types of organisms were recorded, and fouling damage to the coating was noted. After the fouling was examined, the cone and splash zone of each buoy were washed with a high-pressure stream of seawater to remove the fouling and expose coating damage. Two independent ratings of the condition of each buoy and its protective coating system were made in the atmospheric, splash, and submerged zones.

Electrical potential measurements were made on buoys with and without cathodic protection to determine the amount of additional potential produced on cathodically protected buoys. The coating deterioration and corrosion damage of the three cathodically protected buoys was compared to that of the control buoys.

Two independent ratings were also made of the condition of the coating systems on the steel test panels exposed in San Diego Bay and Port Hueneme Harbor. Fouling organisms were carefully removed from one side of each test panel with a wooden scraper and a stiff brush before rating the coating condition in the fouled area.

RATING CRITERIA

As far as possible, the methods of rating the coating on buoys and test panels were those published by the American Society for Testing and Materials.[7] These published methods define the conditions rated and give photographic reference standards. Thus, chalking, blistering, checking, cracking, flaking, erosion, and rusting were rated from 0 to 10 by ASTM methods D-659-44, D-714-56, D-660-44, D-661-44, D-772-47, D-662-44, and D-610-43, respectively. A rating of 10 usually describes a perfect condition, and a rating of 0 describes a completely deteriorated condition. Blistering frequency was rated as none (N), few (F), medium (M), medium dense (MD), or dense (D). Surface areas covered by fouling (plant, animal, or combined fouling) were rated from 0 (100% covered) to 10 (0% covered). Color of the topcoat on [illegible] buoys was also rated from 0 to 10; 10 indicates pure white with no yellowing or other discoloration (except rust streaks from uncoated bolts), and 0 indicates a color unacceptable to the U. S. Coast Guard.

Frequency of use of buoys by the fleet was rated as light (0 to 2 days per week), medium (2 to 4 days per week), or heavy (4 to 7 days per week). Some of the buoys provide bow and stern moorings only, and the rest provide either bow and stern or free-swinging moorings.

The overall condition of each buoy and its coating system was rated as excellent (in essentially the same condition as when first placed in service); good (very minor deterioration); fair (a significant amount of coating deterioration and/or rusting, but still in serviceable condition); and poor (coating deterioration and rusting serious enough to lead to an early removal from service).

The coating system on each test panel was given an overall rating from 0 (minimum protection) to 10 (maximum protection), depending upon both the condition of the entire coating system and the protection afforded to the steel. It was much easier to rate the overall coating conditions on the panels than on buoys because the panels were not abraded during mooring service.

CONDITION OF BUOY COATINGS

Table I describes each coating system. The overall ratings and lengths of service of buoy coatings are summarized in Table II. The proprietary sources of the coatings tested are listed in References 2 through 4. Ratings of specific conditions of coated test buoys are given in Appendix A.

Coating System 1: Urethane

The condition of the System 1 buoy was virtually unchanged since the last rating inspection (Figure 1). The pinpoint corrosion and slight blistering noted initially at that time had not increased to a noticeable extent.

The many patches of underwater-curing epoxy that had been applied 2-1/2 years earlier were still adhering strongly to the steel (Figure 2) despite the previously reported[3,4,5] lifting of the edges of some of the patches.

The fouling on all test buoys was generally similar. Green algae and barnacles were most conspicuous in the splash zone. Tunicates and barnacles were most conspicuous in the submerged zone, and mussels, bryozoa, and tube worms were usually present to a minor extent.

At the time of the last inspection, there were several localized areas of *Teredo* and *Limnoria* damage on the lower wooden fender. At this inspection the untreated lower fenders on the Mark I buoys generally had slight marine borer damage, while the lower creosoted fenders on the Mark II buoys suffered no such damage. The latter fenders were almost always completely out of the water when no ship was secured to the buoys.

Table I. System Description and Coating Thickness

System		Primer			Additional Coats			Total Thickness (mils)
Number	Description	Type	Coats (No.)	Thickness (mils)	Type	Coats (No.)	Thickness (mils)	
1	Urethane	Urethane	1	2	Urethane	3	8	10
2	Epoxy	Epoxy	1	4-5	Epoxy Epoxy Antifouling	1 1 1	4 3 4	8-9 11-12 15-16
3	Epoxy, Polyester	Epoxy	1	4-5	Polyester Antifouling	2 1	5-6 4	9-11 13-15
4	Epoxy - Coal Tar Epoxy	Epoxy	1	4	Coal Tar Epoxy Epoxy Epoxy	1 1 1	4-5 4 4	8-9 12-13 16-17
5	Coal Tar Epoxy - Phenolic	Coal Tar Epoxy	1	5	Phenolic Phenolic	1 1	4-6 6-7	9-11 15-18
6 & 6C	Phenolic Mastic	Mica-filled Phenolic	1	10-11	Phenolic Mastic	1	8-9	18-20
7C	Phenolic	Wash Primer Phenolic	1 2	½ 4½	Phenolic Antifouling	1 1	2-3 3	7-8 8
8	Phenolic Alkyd	Wash Primer Phenolic	1 2	½ 4½	Alkyd Antifouling	1 1	2-3 3	7-8 8
9	Vinyl	Wash Primer Vinyl	1 4	½ 6½-7½	Vinyl-alkyd Antifouling	3 2	4 4	11-12 11-12
10	High-Build Vinyl	Vinyl	1	2	Vinyl Vinyl	2 1	5-6 2	7-8 9-10
11	Vinyl Mastic	Vinyl Phenolic	1	1-2	Vinyl Mastic	2	12-13	13-15
12	Inorganic Zinc Silicate - Vinyl Mastic	Inorganic Zinc Silicate Vinyl Phenolic	1 1	4 1-2	Vinyl Mastic	1	5-6	10-12
13 & 13C	Saran (Formula 113-54)	—	—	—	Saran	8	8	8

Table II. Overall Rating and Length of Service for Coated Buoys

Coating System		Length of Service (days)	Overall Rating
Number	Description		
1	Urethane	1232	good-fair
2	Epoxy	1190	good
3	Epoxy - Polyester	1190	fair
4	Epoxy - Coal Tar Epoxy	1232	good-fair
5	Coal Tar Epoxy - Phenolic	1190	fair
6	Phenolic Mastic	1190	good-fair
6C	Phenolic Mastic	1190	good
7C	Phenolic	1042	good-fair
8	Phenolic - Alkyd	1042	good-fair
9	Vinyl	1064	good
10	High-Body Vinyl	1156	fair
11	Vinyl Mastic	—	removed from test
12	Inorganic Zinc Silicate - Vinyl Mastic	1232	fair
13	Saran	1190	good-fair
13C	Saran	1196	good

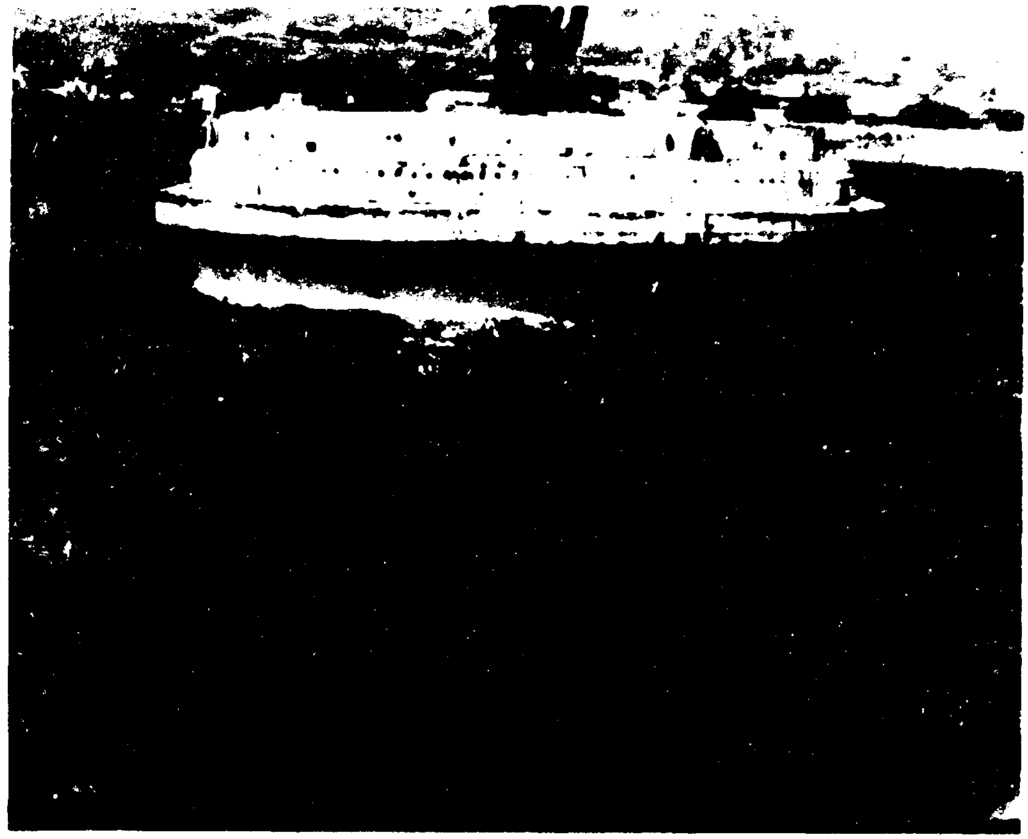


Figure 1. System 1 buoy before removal of fouling.

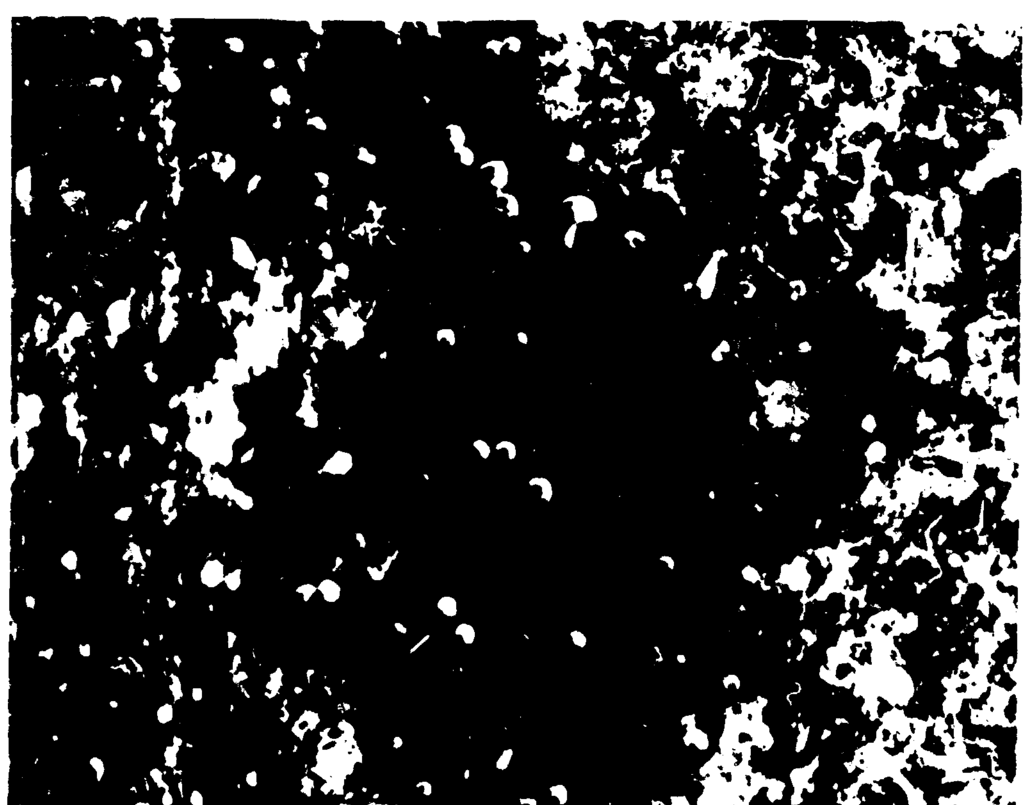


Figure 2. Epoxy patch on cone of System 1 buoy with barnacle fouling.

Coating System 2: Epoxy

The condition of the System 2 buoy was unchanged since the last inspection except for two localized areas where the coating had been abraded to bare steel by severe impact (Figure 3). These areas were manually wire brushed and patched with underwater-curing epoxy (Figure 4). Aside from these areas and the previously noted[5] slight rusting from abrasion damage, the coating system was providing good protection.

Coating System 3: Epoxy - Polyester

The System 3 buoy had been slightly modified by addition of small lights and was replaced into service at the time of the present buoy inspection; because of this, there was no accumulation of guano or fouling on the buoy. The condition of the coating had only slightly changed since the last inspection (Figure 5). The epoxy primer exposed in the submerged zone where much of the polyester topcoats had delaminated, was continuing to protect the underlying steel. There was noted for the first time, blistering of the topcoats to the prime coat in the submerged zone. The slight rusting in all three zones was related to abrasion damage.

Coating System 4: Epoxy - Coal Tar Epoxy

The condition of the System 4 buoy (Figure 6) was essentially unchanged since the previous inspection. The previously reported delamination of the topcoat und seal coat in the submerged zone had not advanced significantly, and the underlying epoxy primer and coal tar epoxy were providing good protection to the steel. Elsewhere, the entire coating system was performing well.

Coating System 5: Coal Tar Epoxy - Phenolic

The condition of the System 5 buoy (Figure 7) was essentially unchanged since the previous inspection. This buoy had suffered extensive abrasion damage in the submerged zone during its first 6 months exposure, but this area has since undergone relatively little further deterioration. The greatly reduced amount of galvanic corrosion previously noted on rivet heads in this area may have occurred after the work-hardened exterior of these heads had been lost. Most of the damage in the atmospheric and splash zones were related to abrasion, especially the top where extensive abrasion by the securing assembly had occurred.

Coating Systems 6 and 6C: Phenolic Mastic

Systems 6 and 6C were identical, but the 6C coating was applied to a cathodically protected buoy. The condition of both buoys (Figure 8) was essentially unchanged since the last inspection. Most of the damage to both buoys was related to abrasion by ships and mooring lines. The better condition of the System 6C buoy was related to (1) the heavier fendering system of the Mark II as compared to the Mark I buoy, (2) the greater resultant freeboard, and (3) the cathodic protection provided. The rust on the submerged portion of the cathodically protected buoy was light, loosely held, and free of pitting. Some of the rusting near the top of this zone may have occurred while the buoy was tilted by a moored vessel.

Coating System 7C: Phenolic

The condition of the System 7C buoy (Figure 9) had not changed appreciably since the last inspection. The medium amount of blistering noted in the submerged zone at the time of the last inspection had not increased appreciably. The gradual erosion of the antifouling coating continued to expose the underlying primer. Additional amounts of the antifouling appeared to be lost during the high-pressure hosing of the fouling organisms. The amount and type of fouling were similar to those on test buoys without antifouling paint. Pinpoint rusting occurred in the tidal zone.

Coating System 8: Phenolic-Alkyd

The condition of the System 8 buoy (Figure 10) had not changed greatly since the last inspection. The submerged portion of this buoy had the identical coating system below the water line as the System 7C buoy, and the condition of both buoys was essentially the same. There was less rusting on the System 7C buoy, however, probably because of the cathodic protection it received. The side of the buoy was quite dirty; the dirt film was rather easily removed, and its source unknown. Rusting on the side was either of the pinpoint variety or had been caused by abrasion.

Coating System 9: Vinyl

The condition of the System 9 buoy (Figure 11) had not greatly changed since the last inspection. There were, however, areas on two small flanges used to secure the lower fender in place where the entire coating system had cracked to the steel and peeled back (Figure 12). From the location of the damaged area, it appears that the cracking may have occurred when a ship struck the buoy and physically displaced the flanges from the position in which they were coated. The loose coating was removed, and a patch of copper oxide-filled underwater-curing epoxy was applied to the wire-brushed surface. The epoxy sagged slightly before it set (Figure 13). The tendency of this particular epoxy to sag has previously been noted in laboratory studies.[8] The type and amount of fouling on this buoy were similar to those on test buoys without an antifouling paint.

Figure 3. Abraded area on System 2 buoy.

Figure 4. Epoxy patches applied to abraded area on System 2 buoy.

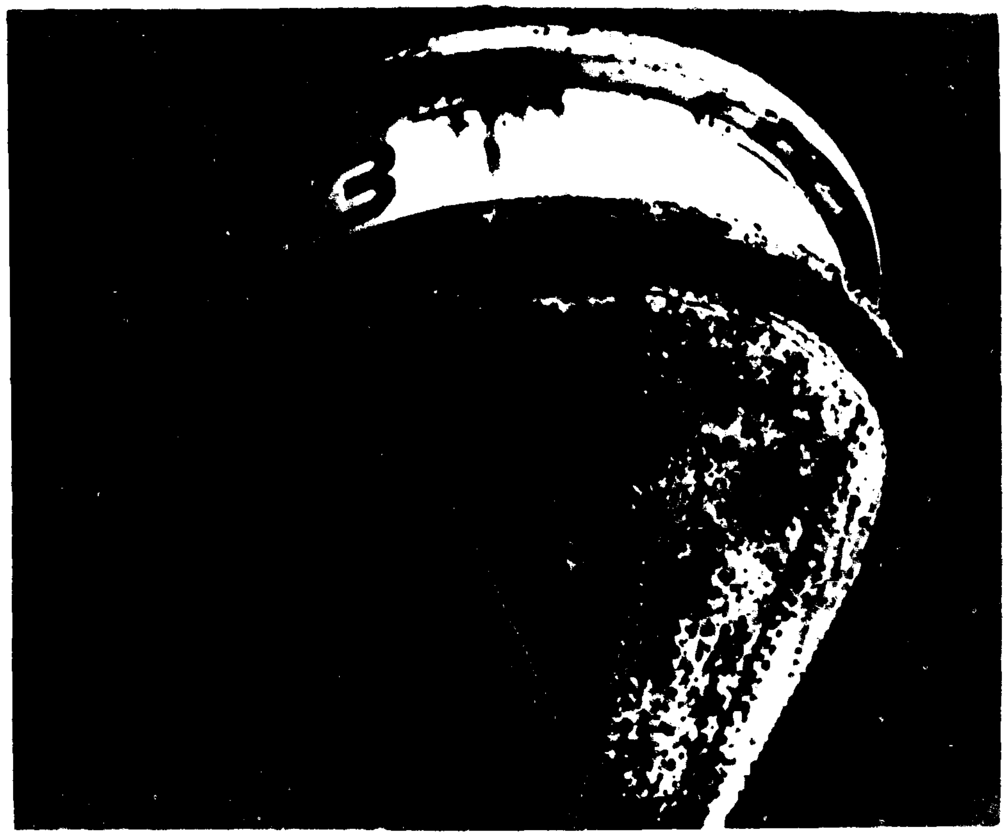


Figure 5. System 3 buoy being returned to service.

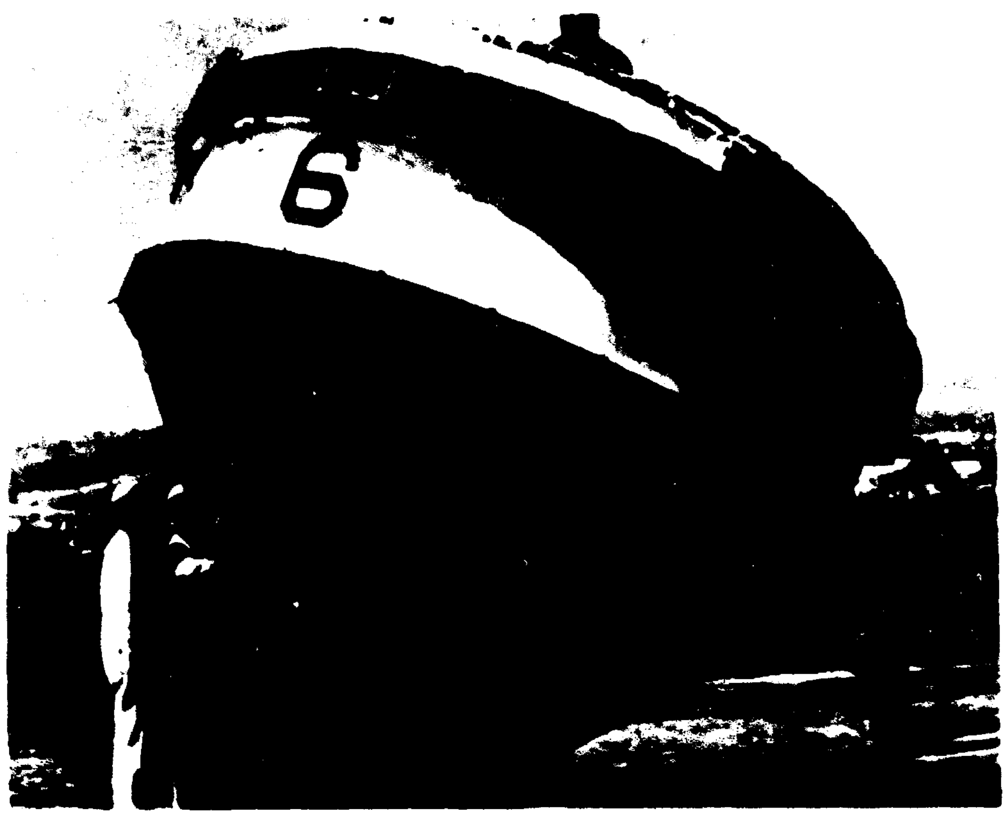


Figure 6. Inspection of System 4 buoy after removal of fouling.

Figure 7. System 5 buoy after removal of fouling.

Figure 8. System 6 buoy after removal of fouling.

Figure 9. System 7C buoy after removal of fouling.

Figure 10. System 8 buoy before removal of fouling.

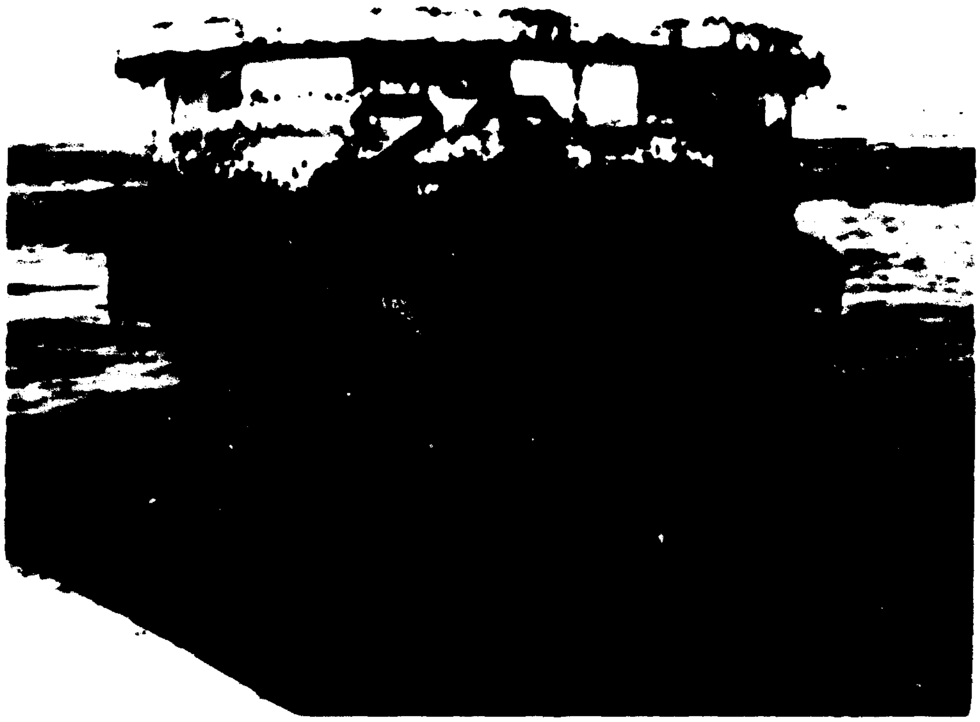


Figure 11. System 9 buoy before removal of fouling.

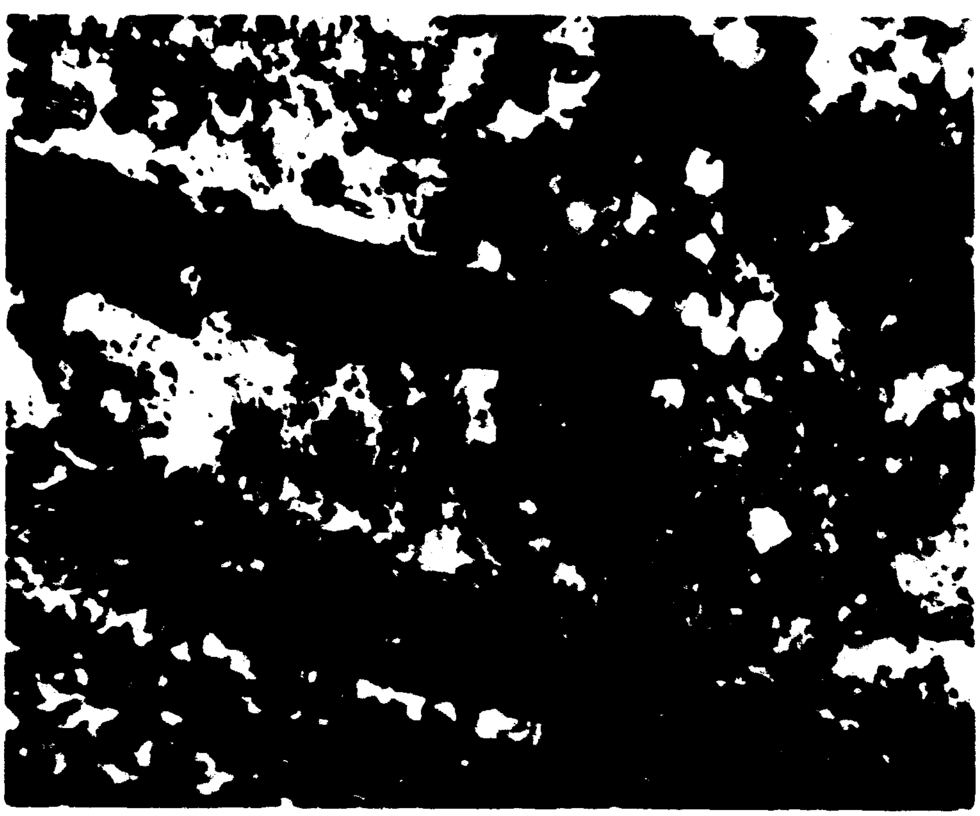


Figure 12. Area on flange where System 9 coating was damaged.

Figure 13. Epoxy patch on flange of System 9 buoy.

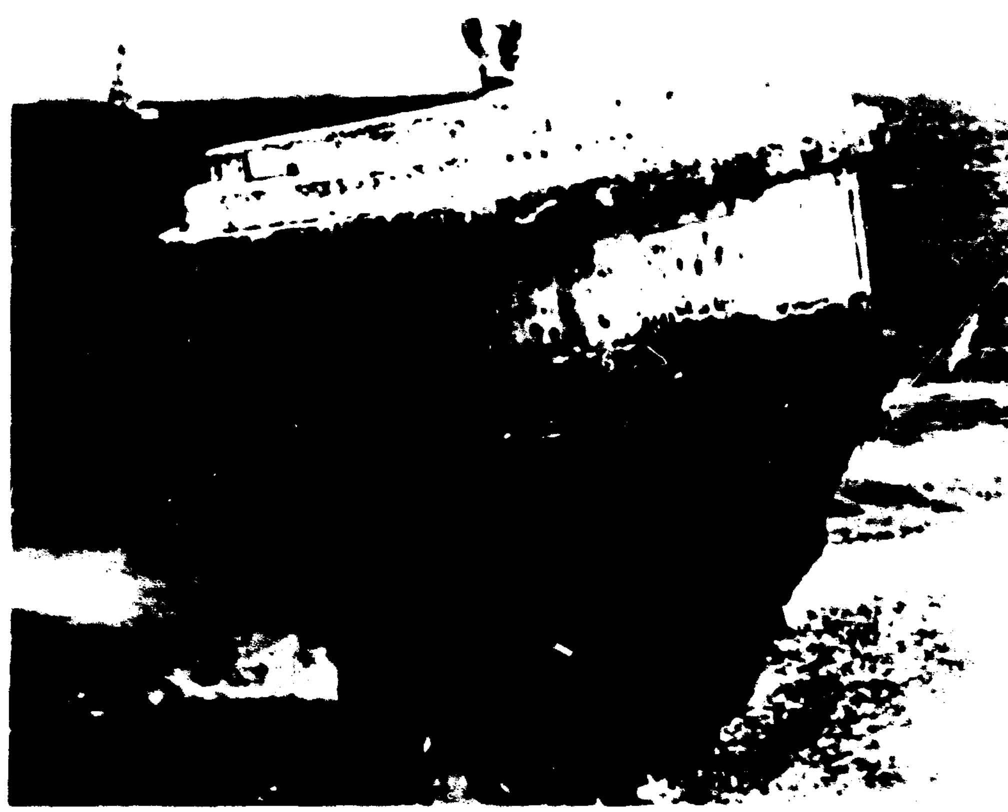


Figure 14. System 10 buoy during removal of fouling.

Coating System 10: High-Body Vinyl

The System 10 buoy continued to show increased blistering of coating, and rusting of exposed steel (Figure 14). Many of the blisters were unbroken and contained yellow water. The steel beneath the unbroken blisters was rust-free. Yellow water had previously been found[9] inside blisters of the same proprietary coating on the interior of a potable-water storage tank. Analysis of both this liquid and of the original primer used on the tank interior showed that chromium was present, even though this was denied by the coating supplier. It appears that osmotic pressure created by the presence of soluble chromium salts may have resulted in blistering both on the buoy and the tank interior.

Because of the advanced deterioration on the splash and submerged zones of the System 10 buoy, it will probably be removed from service in the near future.

Coating System 11: Vinyl Mastic

Because of advanced corrosion, the System 11 buoy was previously removed from testing.

Coating System 12: Inorganic Zinc Silicate - Vinyl Mastic

The condition of the System 12 buoy (Figure 15) had deteriorated only slightly since the last inspection. The slight rusting on the top and side was related to abrasion damage. Although about half of the primer and topcoat had been lost from the submerged zone during the first 6 months, the underlying inorganic zinc silicate has been effective in mitigating corrosion. The slight amount of pinpoint corrosion in this area may be due to a gradual loss of zinc in protecting the steel.

Coating Systems 13 and 13C: Saran

Systems 13 and 13C were identical, but System 13C was applied to a cathodically protected buoy. The former buoy had deteriorated somewhat since the previous inspection while the condition of the cathodically protected buoy was virtually unchanged. The System 13 buoy had extensive abrasion damage on the top caused by the securing assembly. It appeared that some of the pinpoint rust spots in the submerged zone were beginning to pit. The corresponding portion on the System 13C buoy was virtually rust-free (Figure 16).

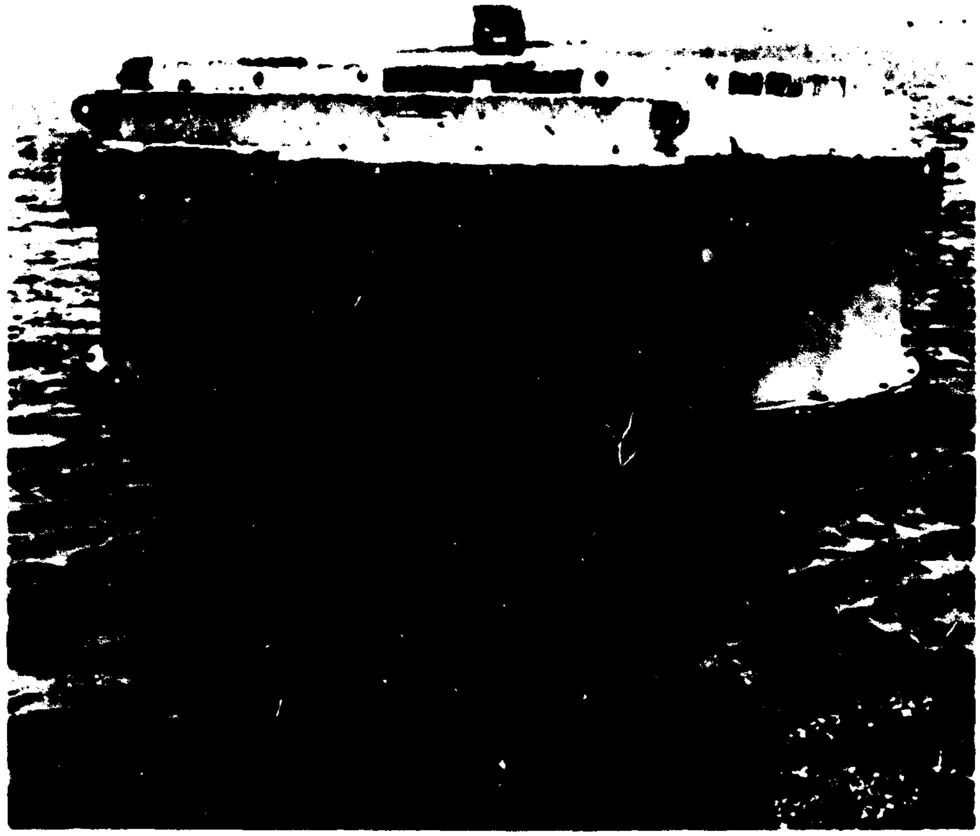


Figure 15. System 12 buoy before removal of fouling.

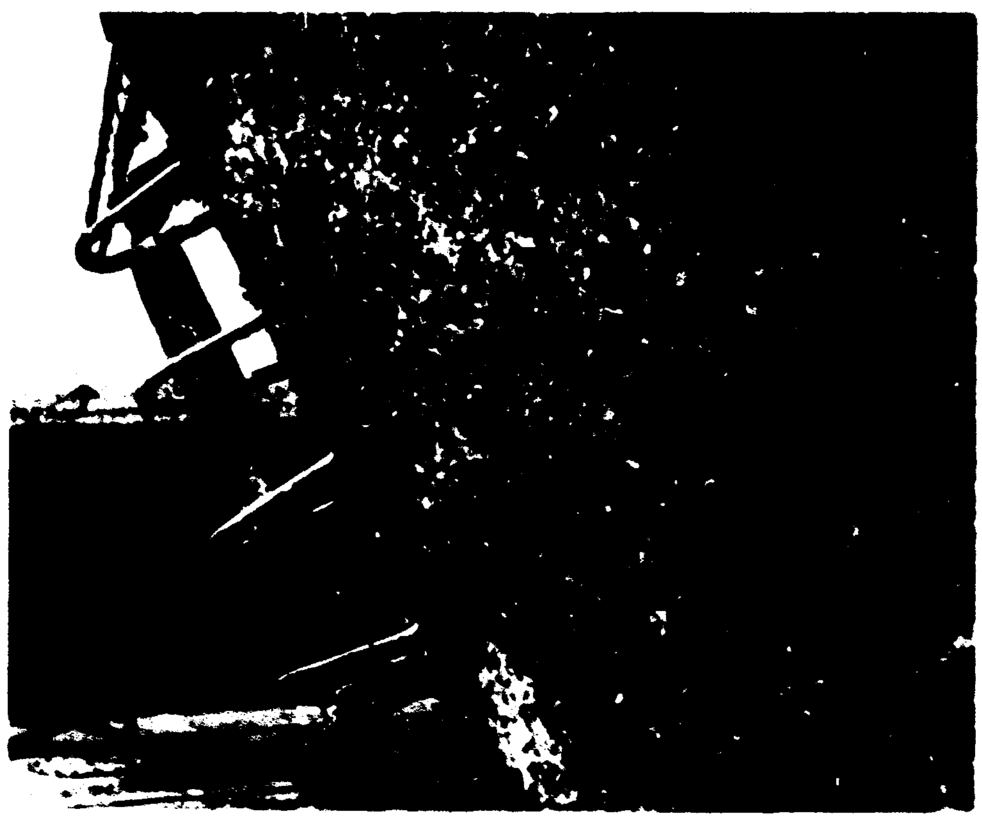


Figure 16. Underwater portion of System 13C buoy after removal of fouling. (Note zinc anode.)

CONDITION OF COATED PANELS

The coating system of each panel is rated in Table III, and the ratings of specific conditions are given in Appendix B.

There continues to be a distinct difference in the type of fouling at both panel locations. While barnacles were conspicuous at both locations, especially in the tidal zone, mussels were much more numerous and larger in size at Port Hueneme. Bryozoa were present in appreciable amounts in Port Hueneme but absent at San Diego. Conversely, tunicates and sponges were most conspicuous in San Diego but virtually absent in Port Hueneme. In Figure 17 is shown the heavy tunicate fouling on the left (deep end) and the heavy sponge fouling on the right (shallow end) of the urethane-coated panel in San Diego. The most conspicuous sponge was identified as Lissodendoryx noxiosa.

Coating System 1: Urethane

Both urethane-coated panels were in fairly good condition. The Type I rusting present on both were of the pinpoint variety. Blistering was noted only on the Port Hueneme panel.

Coating System 2: Epoxy

Both epoxy-coated panels were receiving excellent protection, and no deterioration other than the previously reported loss of antifouling paint was noted.

Coating System 3: Epoxy - Polyester

As previously reported,[4, 5, 6] when the antifouling coat (identical to that of System 2) was lost from the System 3 panels, it took the polyester coats with it exposing the underlying epoxy primer. This primer continues to provide protection at both locations where most of the slight rusting present occurs along the edges. A few blisters were noted initially on the San Diego panels while extensive blistering to the primer has previously been noted on the Port Hueneme panels.

Coating System 4: Epoxy - Coal Tar Epoxy

Neither of the System 4 panels has shown any deterioration other than slight edge rusting on the San Diego panel.

Table III. Overall Ratings of Coated Panels After 2-1/2 Years

Coating System		Ratings[1]	
Number	Description	Port Hueneme	San Diego
1	Urethane	8	9
2	Epoxy	10	10
3	Epoxy - Polyester	9	9
4	Epoxy - Coal Tar Epoxy	10	10
5	Coal Tar Epoxy - Phenolic	9	9
6	Phenolic Mastic	10	10
7C	Phenolic	9	9
8	Phenolic - Alkyd	9	9
9	Vinyl	10	10
10	High-Body Vinyl	8	8
11	Vinyl Mastic	6	6
12	Inorganic Zinc Silicate - Vinyl Mastic	9	9
13	Saran	9	9

[1] 10 = perfect condition; 0 = complete deterioration

Figure 17. Fouling on underwater portion of System 1 panel exposed at San Diego.

Coating System 5: Coal Tar Epoxy - Phenolic

On both System 5 panels there was almost complete loss of the white topcoat, exposing the underlying seal coat in the tidal and submerged zones. The seal coat and primer were providing complete protection for the Port Hueneme panel, and there were only a few blisters and slight edge rusting at San Diego.

Coating System 6: Phenolic Mastic

The System 6 panel showed no deterioration in any zone at Port Hueneme, and only slight edge rusting in the submerged zone in San Diego.

Coating System 7C: Phenolic

There were numerous small blisters in the submerged zone of both System 7C panels but these had not resulted in rusting. The black antifouling coating in this zone was still effective in reducing the amount of fouling organisms as compared to that on panels without an antifouling coating.

Coating System 8: Phenolic - Alkyd

System 8 is identical to that of 7C in the tidal and submerged zones; consequently, the conditions of these two coating systems in these areas were similar. The coating in the atmospheric zones of these systems, though different, were both providing good protection.

Coating System 9: Vinyl

Neither System 9 panel showed deterioration in any zone, except for a partial erosion of the antifouling coating, exposing some of the underlying primer. The fouling of both panels was somewhat less than that on adjacent test panels without an antifouling paint.

Coating System 10: High-Body Vinyl

There were extensive blistering and rusting with pitting on both System 10 panels. The San Diego panel was, however, in slightly better condition than the Port Hueneme panel.

Coating System 11: Vinyl Mastic

Both System 11 panels had extensive rusting and pitting in the tidal and submerged zones, and consequently, were removed from test after inspection.

Coating System 12: Inorganic Zinc Silicate - Vinyl Mastic

On the Port Hueneme System 12 panel, 6% of the vinyl mastic topcoating had been previously lost in the tidal zone, but there was no rusting in any zone because of the protection provided by the inorganic zinc silicate. The San Diego panel had previously lost most of its topcoating in the tidal and submerged zones, and there was slight rusting in these areas.

Coating System 13: Saran

Both System 13 panels were in fairly good condition. Most of the corrosion present consisted of pinpoint or edge rusting.

CATHODIC PROTECTION RESULTS

As previously mentioned, all test buoys were relayed shortly before the inspection. Because of the tightness of the mooring chains, some of the cathodic protection was transferred from the mooring buoy down the riser chain. This had previously been shown[10] to occur with tight moorings. Potentials measured at the time of the inspection of System 6C, 7C, and 13C buoys were -810, -770, and -840 mv, respectively, as compared to a standard silver/silver chloride electrode. Potentials of unprotected buoys were approximately -680 mv. The tension on the 7C riser chain seemed to be greater than that on the other two cathodically protected buoys.

The square of bare steel (Figure 18) previously exposed on the cone of the System 13C buoy by wire brushing[3,4,5,6] had only very light loose rusting and no pitting. The three cathodically protected buoys had less rusting than their corresponding unprotected controls, and the rust was very soft and loosely adhering. After removal of the loose yellowish film from the zinc anodes during the high-pressure hosing of the fouling from the cathodically protected buoys, the anode surface was clean and crystalline. The condition of the loose film and underlying zinc is normal for properly functioning anodes, and no sign of passivation was noted. Relatively little zinc had been lost in protecting the test buoys, and the anodes should continue to provide protection for a long time before anode replacement becomes necessary.

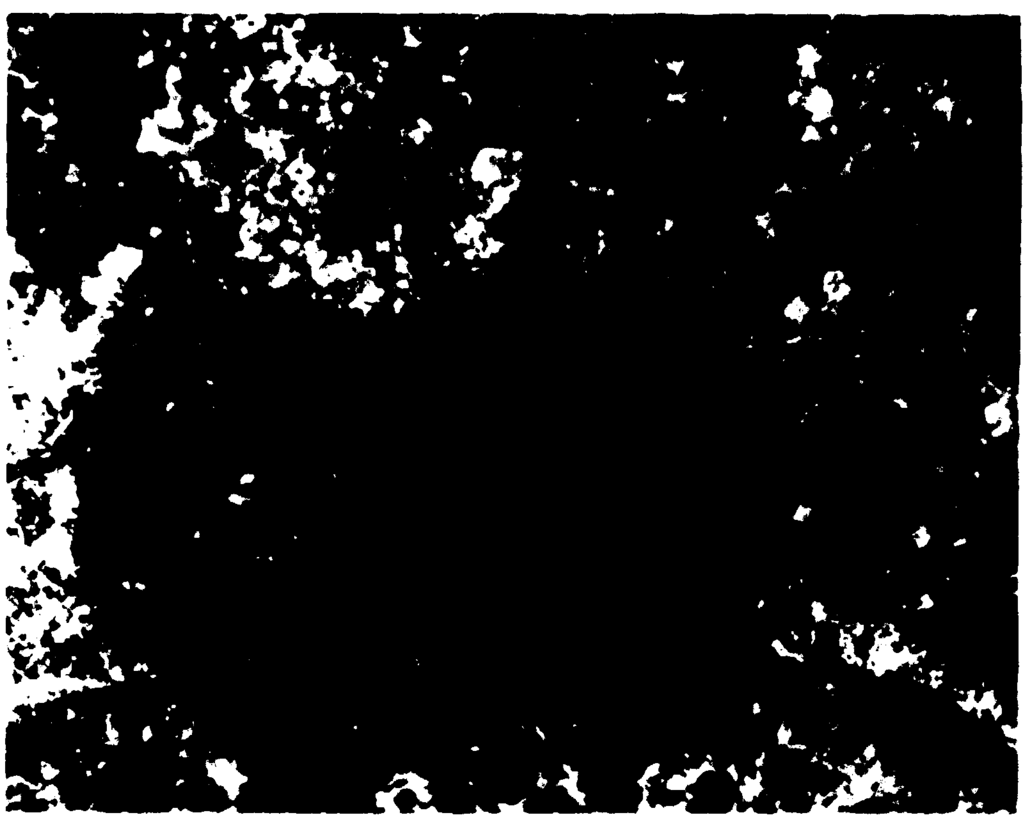


Figure 18. Area of bare steel on cathodically protected System 13C buoy.

DISCUSSION

The condition of the buoy-coating systems at the time of each inspection is summarized in Table IV. From this table it can be seen that relatively little change occurred during the last 6 months. At the time of the present inspection, Systems 2 (epoxy) and 9 (vinyl) were in the best condition. Both, however, had suffered localized coating damage that required patching with underwater-curing epoxies. The indentation of the steel plate where the epoxy system had been badly gashed (Figure 2) indicates that the buoy had received a powerful impact from a vessel. It appears that the damage to the vinyl system (Figure 12) may also have been initiated by the impact of a vessel. Since such damage is inevitable, it seems that the use of cathodic protection in the submerged area and of underwater-curing epoxies to provide protection for damaged areas can result in considerable savings of maintenance funds.

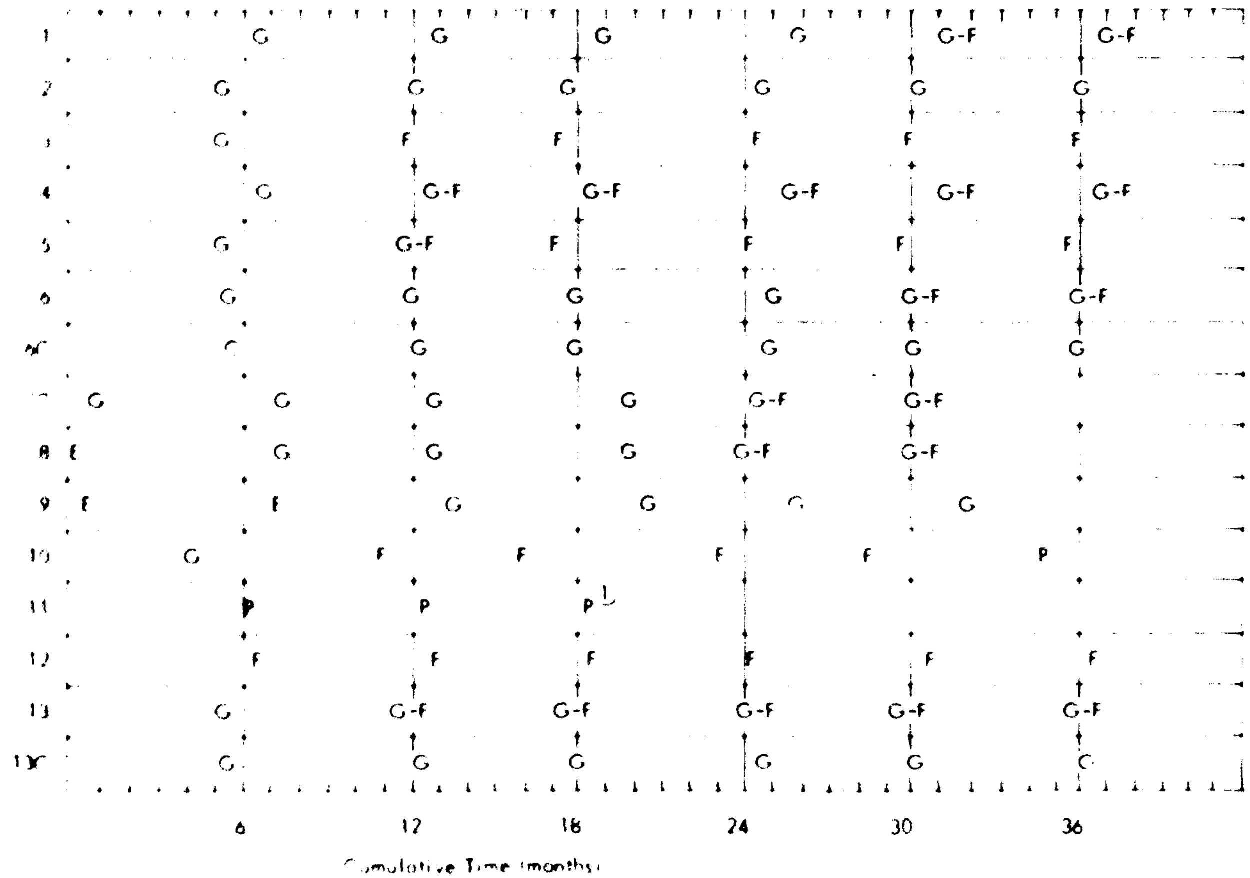
Coating System 1 (urethane) is in fairly good condition. The patches of underwater-curing epoxy applied to abraded areas in the submerged zone at the time of the first inspection have greatly extended the life of the coating system.

Coating Systems 6 (phenolic mastic) and 5 (coal tar epoxy-phenolic) suffered extensive abrasion damage during their first 6 months exposure, suggesting that they were especially susceptible to abrasion damage. Further service to the fleet has not indicated that this is the case.

Coating Systems 7C (phenolic) and 8 (phenolic-alkyd) are still providing fairly good protection. As with the vinyl antifouling paint on Coating System 9, the MIL-P-19449 on the submerged zone of System 7C and 8 buoys has long since eroded to the extent that fouling is no longer reduced. Unlike the vinyl antifouling paint, however, some of the soft MIL-P-19449 appears to have been lost during the high-pressure hosing necessary to remove the fouling before inspection. As previously reported,[6] the longer effectiveness of both antifouling paints on panels than on buoys is due to the fact that the panels are located in quiet waters, while the buoys are located where strong currents leach the toxicants more rapidly.

Because of the limited time during which antifouling paint retards fouling attachment and the fact that detrimental effects of fouling organisms on mooring buoys are still questionable, the use of comparatively costly antifouling paints does not seem justified except in areas where fouling is known to constitute a problem. In order to test the compatibility of System 2 (epoxy) with antifouling paints, one 10-foot panel coated with this system was topcoated in the tidal and submerged zones with a proprietary copper oxide-containing polyester antifouling and another was coated with vinyl antifouling (MIL-P-15931A). After 5-months exposure in Port Hueneme Harbor, both panels showed no deterioration and no appreciable fouling attachment. Suppliers of Coating Systems 1 (urethane) and 6 (phenolic mastic) suppliers state that these products are also compatible with conventional antifouling paints. Should antifouling paints not be desired, the primers of Systems 7C (phenolic) and 9 (vinyl) can be topcoated below the water line with MIL-P-12507A and MIL-P-16738B, respectively, the same as they are above.

Table IV. Condition of Buoy Coatings at Time of Each Inspection[1]



1/ Ratings
E excellent
G good
F fair
P poor

2/ Removed after 19 months

The inorganic zinc silicate of System 12 seems to be losing its effectiveness in retarding corrosion because slight rusting was noted for the first time in areas where the topcoating had previously been lost.

Coating System 13 (saran) showed increased pinpoint corrosion with an indication of the start of pitting in the submerged zone. The System 13C buoy was virtually free of rusting in the submerged zone indicating the effectiveness of the cathodic protection. Saran has not performed as well in the buoy-test program as in the steel-sheet piling study of Alumbaugh et al.[11] A zinc-rich saran coating might perform well in providing protection where pinholing occurs.

In general, the condition of identical coating systems on test panels at both locations and on the test buoys was similar. One notable exception as previously discussed, was the longer effectiveness of antifouling paints on coated panels than on the buoys.

The zinc anodes appeared to be quite effective in mitigating corrosion. The potential values slightly below that desired (-850 mv) and the lack of complete prevention of corrosion are caused by the drain of current down the tight-riser chain. The cathodic protection of both buoys and ground tackle is being investigated in a separate study.[10] No evidence was found of passivation of zinc anodes, as previously noted in San Diego Bay by Peterson and Waidron[12] in earlier work.

FINDINGS

1. On four of the test buoys, the coating systems were in good condition; nine showed varying degrees of intermediate deterioration; one was in poor condition, and another had previously been removed from test because of advanced deterioration.

2. Two antifouling paints on test panels were still effective in reducing the amount of fouling after 2-1/2 years; on test buoys they had lost most of their effectiveness after 20 months.

3. Zinc anodes were effective in mitigating corrosion on test buoys. Some protection was lost down the tight-riser chain.

CONCLUSION

The use of an antifouling paint on mooring buoys intended for more than 2 years service before removal for repairs is not justified, unless fouling is known to be a problem.

ACKNOWLEDGMENT

Mr. C. V. Brouillette of NCEL made an independent rating of the coated buoys and both sets of coated panels.

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Appendix A

RATINGS OF BUOYS WITH TEST COATINGS

Coating System 1: Urethane

No. of Days in Service: 1232

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	4	4	–
Blistering	N, 10	F, 4	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I 1/	9	9	9
Rusting, Type II 2/	10	10	10
Fouling, amount	–	heavy	heavy
Guano, amount	light	–	–
Structural damage	none	none	dent in steel plate

1/ Without blistering.
2/ With blistering.

Coating System 2: Epoxy

No of Days in Service: 1190

Overall Condition: Good

Amount of use: Light

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	6	6	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	–
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	heavy	heavy
Guano, amount	medium	–	–
Structural damage	none	none	dent in steel plate

Coating System 3: Epoxy - Polyester

No. of Days in Service: 1190 | Overall Condition: Fair

Amount of use: Light | Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	8	8	—
Blistering	N, 10	N, 10	MD, 2 [2/]
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	5 [1/]	5 [1/]
Erosion	10	10	10
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	—	heavy	medium
Guano, amount	medium	—	—
Structural damage	fender splintered	none	fender splintered

[1/] Topcoat lost exposing primer.

[2/] Blistering to primer only.

Coating System 4: Epoxy - Coal Tar Epoxy

No. of Days in Service: 1232

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	6	6	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	6 [1]
Erosion	10	10	10
Rusting, Type I	9	9	10
Rusting, Type II	10	10	10
Fouling, amount	—	medium	medium
Guano, amount	light	—	—
Structural damage	none	none	none

[1] Delamination of topcoat and seal coat, exposing coal tar epoxy coating.

Coating System 5: Coal Tar Epoxy - Phenolic

No. of Days in Service: 1190

Overall Condition: Fair

Amount of use: Light

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	6	6	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	9	9 [1]
Rusting, Type II	10	10	10
Fouling, amount	–	heavy	heavy
Guano, amount	light	–	–
Structural damage	none	none	dent in steel plate

[1] Rivet heads were badly corroded.

Coating System 6: Phenolic Mastic

No. of Days in Service: 1190 — Overall Condition: Good

Amount of use: Light — Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	6	6	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	9[1]
Rusting, Type II	10	10	10
Fouling, amount	—	heavy	heavy
Guano, amount	light	—	—
Structural damage	dent in side; broken fender	broken fender	dent in steel plate

[1] Rivet heads were badly corroded.

Coating System 6C: Phenolic Mastic

No. of Days in Service: 1190 Overall Condition: Good

Amount of use: Light Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	light	light
Guano, amount	light	–	–
Structural damage	fender splintered	none	none

Coating System 7C: Phenolic

No. of Days in Service: 1042

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	2	2	—
Blistering	N, 10	N, 10	M, 4
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	9[1]	10
Erosion	10	10	8[2]
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	—	light	heavy
Guano, amount	medium	—	—
Structural damage	none	none	slight dent

[1] A small patch of coating lost from fender flange.
[2] Antifouling paint only.

Coating System 8: Phenolic - Alkyd

No. of Days in Service: 1042

Overall Condition: Good-Fair

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	8	8	—
Blistering	N, 10	N, 10	MD, 4
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	8
Erosion	10	10	9[1]
Rusting, Type I	9	9	9
Rusting, Type II	10	10	9
Fouling, amount	—	medium	heavy
Guano, amount	light	—	—
Structural damage	none	none	none

[1] Antifouling paint only.

Coating System 9: Vinyl

No. of Days in Service: 1064

Overall Condition: Good

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	10	–
Chalking	6	6	–
Blistering	N, 10	N, 10	N, 10
Checking	N, 10	10	10
Cracking	N, 10	10	10
Flaking (scaling)	N, 10	9 1/	10
Erosion	N, 10	10	9 2/
Rusting, Type I	9	9	9
Rusting, Type II	10	10	10
Fouling, amount	–	heavy	heavy
Guano, amount	light	–	–
Structural damage	none	dent in steel plate	dent in steel plate

1/ Two area peeled flanges.
2/ Antifouling paint only.

Coating System 10: High-Body Vinyl

No. of Days in Service: 1156

Overall Condition: Poor

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	F, 2	F, 2
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	8	8
Rusting, Type II	10	10	10
Fouling, amount	–	medium	heavy
Guano, amount	light	–	–
Structural damage	none	fender splintered	none

Coating System 12: Inorganic Zinc Silicate - Vinyl Mastic

No. of Days in Service: 1232

Overall Condition: Fair

Amount of use: Light

Type of Mooring: Bow and Stern

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	10	10	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	5 1/
Erosion	10	10	10
Rusting, Type I	9 2/	9	9
Rusting, Type II	10	10	10
Fouling, amount	—	medium	medium
Guano, amount	light	—	—
Structural damage	none	none	none

1/ Topcoat only
2/ Mostly top edge

Coating System 13: Saran

No. of Days in Service: 1190

Amount of use: Light

Overall Condition: Good-Fair

Type of Mooring: Bow and Stem

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	–
Chalking	8	8	–
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	8	9	8
Rusting, Type II	10	10	9
Fouling, amount	–	1/	1/
Guano, amount	1/	–	–
Structural damage	none	fender splintered; dent in steel plate	none

1/ No fouling or guano present because of recent relocation of buoy.

Coating System 13C: Saran

No. of Days in Service: 1196

Overall Condition: Good

Amount of use: Light

Type of Mooring: Free-Swinging

Condition Rated	Atmospheric	Splash	Submerged
Color	9	9	—
Chalking	8	8	—
Blistering	N, 10	N, 10	N, 10
Checking	10	10	10
Cracking	10	10	10
Flaking (scaling)	10	10	10
Erosion	10	10	10
Rusting, Type I	9	9	10
Rusting, Type II	10	10	10
Fouling, amount	—	light	heavy
Guano, amount	medium	—	—
Structural damage	dent in steel plate	dent in steel plate	none

Coating System No.	1						2					
Exposure Site	PH			SD			PH			SD		
Panel Zone	A[1]	T[2]	S[3]	A	T	S	A	T	S	A	T	S
General Protection	8	8	10	9	9	9	10	10	10	10	10	10
Chalking	4	—	—	15	—	—	2	—	—	—	—	—
Checking	10	10	10	10	10	10	10	10	10	10	10	10
Blistering, size	10	6	10	10	10	10	10	10	10	10	10	10
Blistering, frequency	N[4]	M[8]	N	N	N	N	N	N	N	N	N	N
Flaking	10	8[7]	10	10	10	10	10	10	10	10	10	10
Cracking	10	10	10	10	10	10	10	10	10	10	10	10
Undercutting	10	10	10	10	10	10	10	10	10	10	10	10
Rusting, Type I	8[13]	9	10	9[13]	9[13]	9[13]	10	10	10	10	10	10
Rusting, Type II	10	8	10	10	10	10	10	10	10	10	10	10
Pitting	10	10	10	10	10	10	10	10	10	10	10	10
Fouling, amount	—	M	M	—	H[6]	H	—	M	H	—	M	M
Fouling, area[10]	—	1	0	—	1	1	—	2	3	—	1	2
1. Plant Area	—	4	6	—	8	8	—	6	6	—	8	8
2. Animal Area	—	8	1	—	2	2	—	5	4	—	2	3
a. Tunicates	—	10	10	—	10	4	—	10	10	—	10	4
b. Barnacles	—	9	8	—	2	8	—	6	9	—	2	9
c. Mussels	—	10	3	—	8	8	—	5	8	—	9	9
d. Bryozoa	—	10	5	—	10	10	—	10	6	—	10	10
e. Hydroids	—	10	4	—	10	10	—	9	6	—	10	10
f. Tube Worms	—	10	9	—	10	10	—	10	9	—	10	10
g. Sponges	—	10	10	—	8	6	—	10	10	—	7	9
Overall Rating		8			9			10			10	

1/ A atmospheric zone
2/ T tidal zone
3/ S submerged zone
4/ D dense
5/ N none
6/ H heavy
7/ Delamination of top coats
8/ M medium
9/ L light
10/ 0 100% foule
11/ F few
12/ Antifouling and

1						2						3					
PH			SD			PH			SD			PH			SD		
A1/	T2/	S3/	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
8	8	10	9	9	9	10	10	10	10	10	10	9	9	10	9	9	9
4	—	—	15	—	—	2	—	—	—	—	—	10	—	—	—	—	—
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	6	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8	8
N4/	M8/	N	N	N	N	N	N	N	N	N	N	N	N	N	N	F8/	F
10	8 7/	10	10	10	10	10	10	10	10	10	10	10	2 12/	2 12/	10	1 12/	1 12/
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
[illegible] 13/	9	10	9 13/	9 13/	9 13/	10	10	10	10	10	10	9 17/	9 17/	10	9 17/	9 17/	9 17/
10	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	9
—	M	M	—	H6/	H	—	M	H	—	M	M	—	M	M	—	M	M
—	1	0	—	1	1	—	2	3	—	1	2	—	3	1	—	1	1
—	4	6	—	8	8	—	6	6	—	8	8	—	6	7	—	8	8
—	8	1	—	2	2	—	5	4	—	2	3	—	4	2	—	2	2
—	10	10	—	10	4	—	10	10	—	10	4	—	10	10	—	10	3
—	9	8	—	2	8	—	6	9	—	2	9	—	2	8	—	2	8
—	10	3	—	8	8	—	5	8	—	9	9	—	9	9	—	9	9
—	10	5	—	10	10	—	10	6	—	10	10	—	10	4	—	10	10
—	10	4	—	10	10	—	9	6	—	10	10	—	10	9	—	10	10
—	10	9	—	10	10	—	10	9	—	10	10	—	10	7	—	10	10
—	10	10	—	8	6	—	10	10	—	7	9	—	10	8	—	8	8
8			9			10			10			[illegible]			9		

e

5/ N = none
6/ H = heavy
7/ Delamination of top coats
8/ M = medium

9/ L = light
10/ 0 = 100% fouled; 10 = 0% fouled
11/ F = few
12/ Antifouling and top coat lost exposing primer

B

ORT HUENEME AND SAN DIEGO

4						5						6					
PH			SD			PH			SD			PH			SD		
A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
10	10	10	9	10	9	10	10	10	9	9	9	10	10	10	10	10	9
10	—	—	—	—	—	10	—	—	—	—	—	2	—	—	—	—	—
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	4	4	10	10	10	10	10	10
N	N	N	N	N	N	N	N	N	N	F	F	N	N	N	N	N	N
10	10	10	10	10	10	10	1 16/	2 16/	10	0 16/	0 16/	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	9 17/	10	9 17/	10	10	10	9 17/	9 17/	9 17/	10	10	10	10	10	9 17/
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
—	M	H	—	M	H	—	H	H	—	M	M	—	M	M	—	M	M
—	2	1	—	.	1	—	1	1	—	1	1	—	2	2	—	1	1
—	9	7	—	8	8	—	8	8	—	8	8	—	5	8	—	8	8
—	3	3	—	2	2	—	2	2	—	2	3	—	5	3	—	2	2
—	10	9	—	10	4	—	10	10	—	10	5	—	10	10	—	10	5
—	4	9	—	2	8	—	3	9	—	2	10	—	5	9	—	2	8
—	5	8	—	8	8	—	5	8	—	8	8	—	9	8	—	8	8
—	10	6	—	10	10	—	10	5	—	10	10	—	10	4	—	10	10
—	10	7	—	10	9	—	9	4	—	9	9	—	10	4	—	10	9
—	10	9	—	10	10	—	10	8	—	10	10	—	10	9	—	10	10
—	10	10	—	6	7	—	10	10	—	8	8	—	10	10	—	6	6
10			10			9			9			10			10		

13/ A few pin holes only

14/ Delamination of primer and top coat exposing zinc silicate coating

15/ Impossible to determine chalking on San Diego panels because of extremely high tide at time of inspection

16/ Loss of top coat exposing gray seal coat

17/ Mostly at edge

Continued

Coating System No.	7C						8						
Exposure Site	PH			SD			PH			SD			
Panel Zone	A	T	S	A	T	S	A	T	S	A	T	S	A
General Protection	9	10	10	10	9	10	10	10	10	9	10	10	10
Chalking	4	—	—	—	—	—	2	—	—	—	—	—	8
Checking	10	6	6	10	10	10	10	10	10	10	10	10	10
Blistering, size	10	D	M	10	6	6	10	6	8	10	6	6	10
Blistering, frequency	N	N	N	N	D	D	N	D	F	N	D	D	N
Flaking	10	10	10	10	10	10	10	10	10	10	10	10	10
Cracking	10	10	10	10	10	10	10	10	10	10	10	10	10
Undercutting	10	10	10	10	10	10	10	10	10	10	10	10	10
Rusting, Type I	9	10	10	10	10	10	10	10	10	9	10	10	10
Rusting, Type II	10	10	10	10	10	10	10	10	10	10	10	10	10
Pitting	10	10	10	10	10	10	10	10	10	10	10	10	10
Fouling, amount	—	L 9/	L	—	L	M	—	L	L	—	L	M	—
Fouling, area 10/	—	4	3	—	1	4	—	3	2	—	1	4	—
1. Plant Area	—	6	3	—	8	8	—	4	3	—	8	8	—
2. Animal Area	—	7	8	—	2	4	—	4	3	—	2	4	—
a. Tunicates	—	10	10	—	10	7	—	10	10	—	10	8	—
b. Barnacles	—	9	8	—	3	9	—	9	8	—	2	9	—
c. Mussels	—	10	10	—	9	9	—	10	10	—	10	10	—
d. Bryozoa	—	10	9	—	10	10	—	10	9	—	10	10	—
e. Hydroids	—	10	10	—	10	9	—	10	10	—	10	9	—
f. Tube Worms	—	10	9	—	10	9	—	10	9	—	10	10	—
g. Sponges	—	10	10	—	9	9	—	10	10	—	9	9	—
Overall Rating	9			9			9			9			

1/ A = atmospheric zone
2/ T = tidal zone
3/ S = submerged zone
4/ D = dense
5/ N = none
6/ H = heavy
7/ Delamination of top coats
8/ M = medium
9/ L = ligh
10/ 0 = 100
11/ F = few
12/ Antifouli

A

lix B — RATING OF TEST PANELS AT PORT HUENEME AND SAN DIEGO (Contd)

9						10						11						12		
PH			SD			PH			SD			PH			SD			PH		
	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
0	10	10	10	10	10	8	8	7	9	8	8	9	5	8	9	4	5	10	10	10
3	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—	10	—	—
)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
)	10	10	10	10	10	6	2	2	10	4	4	10	2	2	10	2	2	10	2	2
I	N	N	N	N	N	F	M	M	N	M	D	N	M	F	N	MD	M	N	D	F
)	10	10	10	10	10	10	10	10	10	10	10	10	5	8	10	2	6	10	4[14]	9[14]
)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
)	10	10	10	10	10	10	10	10	10	9	9	10	6	9	10	6	6	10	10	10
)	10	10	10	10	10	8[17]	10	10	9	9	9	9	6	8	9	5	6	10	10	10
)	10	10	10	10	10	8	8	8	10	8	8	10	6	8	10	8	8	10	10	10
)	10	10	10	10	10	9	8	8	10	9	9	10	8	8	10	8	8	10	10	10
	L	L	—	L	M	—	M	H	—	M	L	—	M	H	—	H	H	—	M	M
	3	3	—	2	3	—	2	1	—	1	3	—	1	1	—	1	1	—	2	1
	3	3	—	8	7	—	8	9	—	8	8	—	8	8	—	8	8	—	4	7
	9	10	—	4	8	—	4	2	—	2	4	—	3	1	—	2	2	—	4	1
	10	10	—	10	9	—	10	10	—	10	4	—	10	10	—	10	4	—	10	10
	9	10	—	4	10	—	5	9	—	2	10	—	3	9	—	2	8	—	4	9
	10	10	—	9	9	—	6	5	—	8	9	—	7	2	—	8	8	—	8	2
	10	10	—	10	10	—	10	4	—	10	10	—	10	4	—	10	10	—	10	6
	10	10	—	10	10	—	9	5	—	10	10	—	10	6	—	10	9	—	8	7
	10	10	—	10	9	—	10	9	—	10	10	—	10	9	—	10	10	—	10	9
	10	10	—	8	10	—	10	10	—	9	9	—	10	10	—	6	7	—	10	10
	10			10			8			8			6			6			9	

ht
0% fouled; 10 = 0% fouled
w
ling and top coat lost exposing primer

13/ A few pin holes only
14/ Delamination of primer and top coat exposing zinc silicate coating

15/ Impo...
bec...
16/ Loss
17/ Mos

B

11						12						13					
PH			SD			PH			SD			PH			SD		
A	T	S	A	T	S	A	T	S	A	T	S	A	T	S	A	T	S
9	5	8	9	4	5	10	10	10	10	8	9	9	9	10	9	9	8
10	—	—	—	—	—	10	—	—	—	—	—	10	—	—	—	—	—
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	2	2	10	2	2	10	2	2	10	10	2	10	10	10	10	10	10
N	M	F	N	MD	M	N	D	F	N	N	M	N	N	N	N	N	N
10	5	8	10	2	6	10	4 14/	9 14/	10	0 14/	2 14/	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
10	6	9	10	6	6	10	10	10	10	10	10	10	10	10	10	10	10
9	6	8	9	5	6	10	10	10	10	9	9	9	9	10	9	9	8
10	6	8	10	8	8	10	10	10	10	10	10	10	10	10	10	10	10
10	8	8	10	8	8	10	10	10	10	10	10	10	10	10	10	10	10
—	M	H	—	H	H	—	M	M	—	M	M	—	H	H	—	M	M
—	1	1	—	1	1	—	2	1	—	3	3	—	4	2	—	1	1
—	8	8	—	8	8	—	4	7	—	7	8	—	7	7	—	8	8
—	3	1	—	2	2	—	4	1	—	5	4	—	7	3	—	2	2
—	10	10	—	10	4	—	10	10	—	9	7	—	10	10	—	10	4
—	3	9	—	2	8	—	4	9	—	8	10	—	6	9	—	2	9
—	7	2	—	8	8	—	8	2	—	10	8	—	5	3	—	9	9
—	10	4	—	10	10	—	10	6	—	10	10	—	10	8	—	10	10
—	10	6	—	10	9	—	8	7	—	10	10	—	8	4	—	10	10
—	10	9	—	10	10	—	10	9	—	10	9	—	10	9	—	10	9
—	10	10	—	6	7	—	10	10	—	8	7	—	10	10	—	6	8
6			6			9			9			9			9		

pin holes only
...ination of primer and top coat
...ng zinc silicate coating

15/ Impossible to determine chalking on San Diego panels because of extremely high tide at time of inspection
16/ Loss of top coat exposing gray seal coat
17/ Mostly at edge

C

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13 ABSTRACT

This is the seventh of a series of reports on the protection of mooring buoys. Fourteen test buoys were given their sixth rating for extent of coating deterioration, corrosion of steel, and fouling. A fifteenth buoy had been removed from testing at the time of the fourth inspection because of advanced deterioration. The coating systems on four of the buoys were in good condition, those on nine others showed varying degrees of moderate deterioration, and one was in poor condition. Two sets of thirteen test panels each, coated with the different coating systems used on the buoys, were given their fifth rating inspection after 2-1/2 years of service. One set was exposed in San Diego Bay and the other in Port Hueneme Harbor. The condition of the coating systems on the Port Hueneme panels showed a general correlation with the test panels and buoys in San Diego. On buoys coated with antifouling paints, no detectable antifouling protection remained after 25 months, but on the test panels at both locations, two antifouling paints were still reducing fouling after 2-1/2 years.

Three of the test buoys were cathodically protected with zinc anodes. The level of protection was high enough to mitigate rusting in the underwater portions of these buoys.

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Fouling						
Antifouling						
Chalking						
Blistering						
Flaking						
Erosion						